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TECHNICAL REPORT
69-86-FL

EFFECT OF FREEZE-THAW CYCLING ON THE VITAMIN CONTENT OF THE MEAL, READY-TO-EAT, INDIVIDUAL

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UNITED STATES ARMY
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EFFECT OF FREEZE-THAW CYCLING ON THE VITAMIN CONTENT OF THE MEAL, READY-TO-EAT, INDIVIDUAL

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Miriam H. Thomas and Doris E. Sherman

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FOREWORD

Four types of military characteristics - nutritional adequacy, acceptability, stability, and field utility - must be met in a successful ration. Failure in any one criteria will result in failure to provide the soldier with suitable foods in order to maintain his fighting efficiency.

Operational rations consist of processed foods which may be stored for extended periods of time at unfavorable or fluctuating temperatures. Invariably, loss of nutrients, particularly vitamins, occur. For this reason, constant testing of prototype foods and follow-up ration design assures that nutritional criteria for the particular ration under study are met.

In recent years, the Services have increasingly emphasized the necessity to reduce weight and volume of rations and to increase ease of preparation for consumption. The Meal, Ready-to-Eat, Individual, : the replacement for the Meal, Combat, Individual, meets these criteria through use of convenience foods and flexible packaging.

This study determined the effect of repeated freezing and thawing upon the vitamin content of the Meal, Ready-to-Eat, Individual.

Appreciation is expressed to Mrs. Mary Ann Wall (Data Analysis Office), Mr. John Swift and Mr. Roy Horreil (Food Laboratory), for their valuable assistance.

The work reported was conducted under Project No. 1J6-64712 D548, Combat Feeding Systems.

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ABSTRACT

A study was conducted to determine the vitamin stability of the Meal, Ready-to-Eat, Individual, after exposure to 1, 3, and 6 freeze-thaw cycles under controlled conditions. Prior to and after cycling, replicate analyses of thirteen menu composites were made for vitamin A, carotene, ascorbic acid, thiamine, riboflavin, niacin, and vitamin B_6 contents. Of these vitamins, losses occurred in all except riboflavin and niacin.

INTRODUCTION

Military interest has focused on the characteristics which make convenience foods adaptable for use by the Armed Forces. Such qualities as ease and speed of preparation in the field, long shelf life, and savings of space and weight have encouraged their use. Additionally, it was expected that many of these foods would be more stable and palatable than conventionally canned foods.

The Meal, Ready-to-Eat, Individual is one of the rations designed to simplify combat feeding by the use of convenience foods. Intended as a replacement for the Meal, Combat, Individual, the Meal, Ready-to-Eat, Individual is composed of twelve flexibly packaged menus, plus two alternative menus. Each menu is a complete meal, and provides at least 1200 calories and one-third of the daily nutrient requirement as specified in AR 40-25 (1969). Except for the reconstitution of the beverages, there is no preparation necessary for the meals. The meals can be eaten cold or heated. Heat processed foods, dehydrated foods, bread rolls, baked desserts, cereal bars, cheese spread, jelly or peanut butter are components of these menus. The majority of the meat components are thermostabilized rather than dehydrated.

In order to determine whether the Meal, Ready-to-Eat, Individual would meet the stability requirements as set forth in the technical characteristics (Appendix 1), several cases were subjected to freezing and thawing cycles under controlled conditions. Analyses of menu[1] composites were made prior to and after cycling to determine nutrient stability.

PROCEDURE

All items were packaged in mylar-foil-polyethylene laminated bags or pouches. The heat-processed meat items had an additional paperboard folder overwrap. The baked items were overpacked in a paperboard box. The packaged components were then packed in a cardboard meal carton (4-3/4 x 2-1/2 x 7-1/4 in.). Case lot samples were subjected to 1, 3, and 6 freeze-thaw cycles. All of the cases in each lot were exposed simultaneously to the test conditions. The temperature conditions and the time of exposure at each temperature are given in Table 1.

Two lots of samples were handled concurrently; one lot was exposed to -54°C while the other lot was thawing. During the first cycle at -54°C for 16 hours, the internal temperature of the cases bottomed at -52° to -54°C. After the cases remained at 22°C for 24 hours followed by 2 hours at 51°C, the internal temperature varied from 22° to 28°C. After remaining at 22°C for 4 additional hours, the temperature was 24°C (See Appendix 2). As soon as the cycling of each lot was completed,

1 Of the fourteen (14) menus available, only thirteen (13) were used in this study.

the cases were transferred to a room with a controlled temperature of 4.5°C and held until analyzed.

Prior to analysis components from each of thirteen menus were composited separately and thoroughly homogenized with an equal weight of water by blending in a Waring blendor. The components of each menu which were combined are given in Table 2. Not all products of each menu were included because they were either fortified or known from previous analytical experience with ration composites to impose analytical problems.

Three individual composites of each menu were analyzed in duplicate. Analyses for vitamin A, carotene, ascorbic acid (reduced and total), thiamine, riboflavin, niacin and vitamin B_6 (1) were made initially and after 1, 3, and 6 freeze-thaw cycles.

RESULTS AND DISCUSSION

Vitamin content as analyzed prior to and after cycling has been given with the standard deviation for each value in Tables 3 through 10. Each value represents at least duplicate assays on each of three composites. All data have been treated statistically by analysis of variance.

The results show that nine of thirteen menus significantly decreased in vitamin A and carotene content. The first cycle was most detrimental as there was 44% and 28% destruction of vitamin A and carotene, respectively. Additional cycling caused a further 13% decrease in vitamin A content but little carotene destruction (Tables 3 and 4).

The data show that the initial content of reduced ascorbic acid decreased one-quarter after one cycle and one-half after six cycles (Table 5). Although the total ascorbic acid content decreased one-quarter after the first cycle, it appeared to return to its original content after the third cycle, and to increase one-quarter after the sixth cycle (Table 6). It is believed that the values reported may include the measurement of reductones formed during storage which have been shown to interfere with the measurement of total ascorbic acid in the method employed (1).

For most menus, the thiamine content decreased approximately 20% during the first cycle and no further loss was encountered (Table 7).

The riboflavin content, on the other hand, increased as the number of cycles increased (Table 8). The phenomenon of increased riboflavin content at elevated temperatures has been reported previously (2, 3, 4). The significant increase in

riboflavin content (22% and 70% increase after the first and sixth cycle respectively) does not result from storage at elevated temperatures, and is consistent throughout all menus (Table 8).

Menu by menu, the majority of the changes in niacin content were not significant (Table 9). However, during the cycling periods, the niacin content seemed to increase. Niacin is considered to be stable under most conditions of storage and is judged to be stable in this case.

As might be expected, the vitamin B_6 content decreased during cycling (Table 10). At the end of the third cycle, there was a 13% reduction in vitamin B_6 content, and by the end of the sixth cycle, an additional 7% loss of vitamin B_6 had occurred.

SUMMARY

Analyses of the Meal, Ready-to-Eat, Individual for vitamin content initially and after 1, 3, or 6 freeze-thaw cycles show vitamin losses similar to those occurring during other storage conditions. Losses in vitamin content ranged from 9% to 50% for vitamin B_6, thiamine, carotene, ascorbic acid and vitamin A. The smallest loss occurred in vitamin B_6 content; the greatest, vitamin A. No loss in niacin content occurred. Riboflavin content increased during cycling.

TABLE 1

Conditions for Freeze-Thaw Cycles

Temperature °C	Time of Exposure Hours
-54	16[1]
22	24
51	2
22	4

1 During the 16 hour hold at -54°C, the temperature of representative food items stabilized between -52° and -54°C.

TABLE 2

Menus of the Meal, Ready-to-Eat, Individual[1]

Menu 1 a

- Chicken loaf
- Peaches
- Apricot cereal bar
- Bread roll
- Jelly
- Chocolate bar with almonds
- Coffee
- Cream substitute
- Sugar

Menu 2

- Bacon
- Beans with tomato sauce
- Apricots[2]
- Bread roll
- Cheese spread
- Cookies, chocolate covered
- Coffee
- Cream substitute
- Sugar

Menu 3

- Ham and chicken loaf
- Bread roll
- Peanut butter
- Chocolate nut roll
- Peaches
- Coffee
- Cream substitute
- Sugar
- Catsup

Menu 4

- Beef patties
- Soup and gravy base, beef
- Beans with tomato sauce
- Bread roll
- Cheese spread
- Cocoa
- Peaches
- Coffee
- Cream substitute
- Sugar
- Catsup

Menu 4 a

- Beef loaf
- Beans with tomato sauce
- Bread roll
- Peanut butter
- Raisin nut cake
- Coffee
- Cream substitute
- Sugar

Menu 5

- Barbecue beef
- Potato pattie
- Bread roll
- Peanut butter
- Strawberries
- Fudge bar
- Coffee
- Cream substitute
- Sugar

Menu 6

- Chicken a la king
- Crackers
- Cheese spread
- Date pudding
- Vanilla cream bar
- Fruit tablets
- Coffee
- Cream substitute
- Sugar

Menu 7

- Ground beef in pickle flavored sauce
- Potato pattie
- Bread roll
- Cheese spread
- Cookie, chocolate covered
- Fruit tablet
- Coffee
- Cream substitute
- Sugar

Menu 8

- Beef stew
- Crackers
- Peanut butter
- Pound cake
- Orange cereal bar
- Coffee
- Cream substitute
- Sugar

1 Only underlined items were composited.
2 Pears may be substituted.

TABLE 2 (Cont'd)

Menus of the Meal, Ready-to-Eat, Individual[1]

Menu 9	Menu 10	Menu 11
Frankfurters	Sausage links	Beef steak
Bread roll	Orange cereal bar	Bread roll
Jelly	Bread roll	Jelly
Chocolate covered brownies	Cheese spread	Fruitcake
Coffee	Apricots[2]	Chocolate bar with almonds
Cream substitute	Coffee	Coffee
Sugar	Cream substitute	Cream substitute
Catsup mix	Sugar	Sugar
	Catsup mix	Catsup mix

Menu 12
Chicken loaf
Potato pattie
Bread roll
Jelly
Cocoa
Orange-nut roll
Coffee
Cream substitute
Sugar
Catsup mix

1 Only the underlined items were composited.

2 Peaches may be substituted.

TABLE 3

Vitamin A Content of Meal, Ready-to-Eat, Individual, During Cycling
I.U./100 gms

Cycles	Menus												
	1a	2	3	4	4a	5	6	7	8	9	10	11	12
0[a]	191 ± 35[e]	123 ±59	193 ±50	302 ±69	353 ±66	347 ±78	335 ±42	496 ±132	257 ±90	284 ±103	305 ± 87	272 ±86	291 ±93
1[b]	160 ± 15	145 ±12	118 ±18	221 ±84	159 ±53	191 ±27	243 ±51	290 ± 67	189 ±51	88 ± 16	154 ± 28	110 ±30	101 ±38
3[c]	193 ±106	158 ±71	148 ±87	130 ±84	123 ±55	162 ±51	217 ±53	281 ± 72	202 ±82	135 ± 61	155 ±108	111 ±35	108 ±64
6[d]	112 ± 12	138 ± 6	134 ± 8	173 ±14	96 ±12	162 ±11	182 ±24	182 ± 6	122 ±20	101 ± 5	115 ± 4	60 ± 8	68 ± 6
Significance level	NS	NS	NS	0.05	0.01	0.01	0.05	0.05	NS	0.05	0.05	0.05	0.05

a Fourteen (14) observations, except twelve (12) for Menu 1 a.

b Eight (8) observations.

c Eight (8) observations, except eleven (11) for Menu 12.

d Six (6) observations.

e Standard deviation.

TABLE 4

Carotene Content of Meal, Ready-to-Eat, Individual, During Cycling
mg/100 gms

Cycles	Menus												
	1a	2	3	4	4a	5	6	7	8	9	10	11	12
0[a]	0.301 ±0.13[d]	1.99 ±0.18	0.320 ±0.12	1.81 ±0.33	1.47 ±0.24	2.89 ±0.41	0.411 ±0.16	2.87 ±0.31	1.04 ±0.29	0.216 ±0.08	0.524 ±0.15	0.131 ±0.05	0.196 ±0.09
1[b]	0.154 ±0.06	0.475 ±0.54	0.174 ±0.10	1.33 ±0.21	1.17 ±0.10	3.08 ±0.25	0.215 ±0.05	2.53 ±0.47	0.57 ±0.22	0.182 ±0.09	0.169 ±0.07	0.100 ±0.05	0.104 ±0.03
3[b]	0.096 ±0.06	1.59 ±0.57	0.255 ±0.[illegible]	1.53 ±0.12	1.12 ±0.24	2.29 ±0.48	0.156 ±0.08	3.13 ±0.30	1.06 ±0.20	0.059 ±0.01	0.125 ±0.06	0.022 ±0.01	0.035 ±0.05
6[c]	0.115 ±0.02	1.63 ±0.28	0.083 ±0.01	1.22 ±0.28	1.07 ±0.03	2.53 ±0.13	0.037 ±0.005	3.04 ±0.04	1.10 ±0.14	0.068 ±0.01	0.110 ±0.00	0.030 ±0.01	0.052 ±0.01
Significance level	0.05	0.05	NS	0.05	0.05	NS	0.05	NS	NS	0.05	0.01	0.05	0.05

[a] Fourteen (14) observations, except twelve (12) for Menu 1a.

[b] Eight (8) observations.

[c] Six (6) observations.

[d] Standard deviation.

TABLE 5

Reduced Ascorbic Acid Content of Meal, Ready-to-Eat, Individual, During Cycling
mg/100 gms

Cycles	Menus 1a	2	3	4	4a	5	6	7	8	9	10	11	12
0[a]	2.3 ±0.34[b]	0.90 ±0.76	2.4 ±0.69	2.3 ±0.45	2.2 ±0.17	4.9 ±0.60	2.0 ±0.30	2.4 ±0.35	1.6 ±0.38	1.3 ±0.27	1.4 ±0.26	2.4 ±0.30	1.0 ±0.48
1[a]	1.6 ±0.30	1.09 ±0.20	1.1 ±0.14	1.0 ±0.22	1.4 ±0.19	2.4 ±1.02	1.8 ±0.34	1.7 ±0.56	1.8 ±0.92	2.3 ±0.93	1.5 ±0.47	1.8 ±0.45	1.5 ±0.28
3[a]	2.0 ±0.74	0.96 ±0.16	2.3 ±0.87	1.1 ±0.43	1.7 ±0.26	1.4 ±0.30	2.4 ±0.97	1.5 ±0.20	2.5 ±0.76	1.2 ±0.23	1.7 ±0.43	2.7 ±0.55	1.2 ±0.15
6[a]	0.63 ±0.52	0.20 ±0.28	0.60 ±0.93	1.5 ±0.82	0.58 ±0.47	2.8 ±2.17	1.2 ±0.36	1.3 ±0.46	1.1 ±0.56	1.1 ±1.0	0.65 ±0.30	1.4 ±0.35	0.31 ±0.70
Significance level	0.05	NS	0.05	NS	0.01	NS	NS	NS	NS	NS	0.05	0.05	NS

a Six (6) observations.

b Standard deviation.

TABLE 6

Total Ascorbic Acid Content of Meal, Ready-to-Eat, Individual, During Cycling
mg/100 gms

Cyc s	Menus												
	1a	2	3	4	4a	5	6	7	8	9	10	11	12
0[a]	4.8 ±2.1[b]	7.3 ±1.3	5.4 ±1.2	3.0 ±0.24	5.6 ±1.1	14.7 ±0.78	5.8 ±0.51	3.0 ±0.14	3.0 ±0.55	4.5 ±2.7	3.7 ±0.82	6.2 ±2.8	2.4 ±0.70
1[a]	2.3 ±0.21	5.5 ±0.16	4.7 ±1.0	2.6 ±0.40	4.6 ±0.51	9.7 ±1.1	4.1 ±0.31	2.9 ±0.68	3.0 ±0.29	4.1 ±3.5	2.8 ±1.8	2.4 ±0.68	2.3 ±0.43
3[a]	4.5 ±1.8	9.6 ±1.4	6.5 ±0.40	3.4 ±0.19	5.8 ±0.29	16.9 ±3.0	5.1 ±1.4	4.0 ±0.36	3.7 ±0.13	6.0 ±5.0	3.5 ±0.44	3.6 ±0.15	2.9 ±0.21
6[a]	4.9 ±2.3	9.8 ±2.0	9.1 ±2.3	3.8 ±0.81	6.7 ±1.7	20.6 ±4.1	6.1 ±1.3	5.3 ±0.97	5.5 ±1.2	4.6 ±0.43	6.7 ±2.9	4.5 ±1.0	3.3 ±0.65
Significance level	NS	0.05	0.05	NS	NS	0.05	NS	0.05	0.05	NS	NS	NS	NS

[a] Six (6) observations.

[b] Standard deviation.

TABLE 7

Thiamine Content of Meal, Ready-to-Eat, Individual, During Cycling
mg/100 gms

Cycles	Menus												
	1a	2	3	4	4a	5	6	7	8	9	10	11	12
0[a]	0.088 ±0.004[b]	0.202 ±0.04	0.145 ±0.01	0.087 ±0.01	0.070 ±0.01	0.037 ±0.02	0.040 ±0.01	0.030 ±0.01	0.028 ±0.004	0.100 ±0.01	0.142 ±0.01	0.045 ±0.005	0.052 ±0.01
1[a]	0.028 ±0.01	0.138 ±0.01	0.105 ±0.01	0.075 ±0.005	0.052 ±0.004	0.033 ±0.005	0.038 ±0.01	0.035 ±0.01	0.025 ±0.005	0.077 ±0.01	0.103 ±0.01	0.033 ±0.005	0.035 ±0.005
3[a]	0.023 ±0.005	0.142 ±0.004	0.097 ±0.005	0.080 ±0.00	0.063 ±0.005	0.038 ±0.004	0.037 ±0.005	0.038 ±0.01	0.020 ±0.00	0.075 ±0.005	0.097 ±0.01	0.032 ±0.004	0.047 ±0.01
6[a]	0.057 ±0.03	0.150 ±0.01	0.105 ±0.01	0.087 ±0.01	0.065 ±0.005	0.043 ±0.01	0.062 ±0.02	0.035 ±0.005	0.028 ±0.01	0.073 ±0.01	0.107 ±0.01	0.052 ±0.02	0.043 ±0.01
Significance level	0.05	0.05	0.01	NS	NS	NS	NS	NS	NS	0.05	0.05	NS	NS

[a] Six (6) observations.

[b] Standard deviation.

TABLE 8

Riboflavin Content of Meal, Ready-to-Eat, Individual, During Cycling
mg/100 gms

Cycles	Menus												
	1a	2	3	4	4a	5	6	7	8	9	10	11	12
0[a]	0.239 $\pm$0.06[d]	0.202 $\pm$0.03	0.232 $\pm$0.04	0.174 $\pm$0.06	0.197 $\pm$0.07	0.136 $\pm$0.08	0.165 $\pm$0.04	0.147 $\pm$0.03	0.131 $\pm$0.02	0.139 $\pm$0.03	0.176 $\pm$0.02	0.049 $\pm$0.04	0.091 $\pm$0.03
1[b]	0.163 $\pm$0.02	0.177 $\pm$0.02	0.200 $\pm$0.01	0.185 $\pm$0.02	0.168 $\pm$0.04	0.140 $\pm$0.02	0.258 $\pm$0.02	0.270 $\pm$0.04	0.214 $\pm$0.03	0.175 $\pm$0.02	0.253 $\pm$0.01	0.192 $\pm$0.04	0.170 $\pm$0.04
3[c]	0.185 $\pm$0.02	0.165 $\pm$0.01	0.198 $\pm$0.01	0.192 $\pm$0.01	0.187 $\pm$0.01	0.173 $\pm$0.02	0.265 $\pm$0.04	0.260 $\pm$0.05	0.190 $\pm$0.02	0.172 $\pm$0.01	0.247 $\pm$0.01	0.183 $\pm$0.01	0.173 $\pm$0.01
6[c]	0.258 $\pm$0.04	0.238 $\pm$0.01	0.275 $\pm$0.03	0.268 $\pm$0.03	0.315 $\pm$0.05	0.268 $\pm$0.01	0.342 $\pm$0.05	0.360 $\pm$0.03	0.223 $\pm$0.02	0.233 $\pm$0.03	0.302 $\pm$0.05	0.222 $\pm$0.05	0.217 $\pm$0.04
Significance level	NS	0.05	0.05	0.05	0.05	0.05	0.05	0.01	0.05	0.05	0.05	0.01	0.05

[a] Eight (8) observations.

[b] Six (6) observations, except eight (8) for Menus 7, 8, 11 and 12.

[c] Six (6) observations.

[d] Standard deviation.

TABLE 9

Niacin Content of Meal, Ready-to-Eat, Individual, During Cycling
mg/100 gms

Cycles	Menus												
	1a	2	3	4	4a	5	6	7	8	9	10	11	12
0[a]	2.16 ±0.22[d]	1.13 ±0.15	1.63 ±0.25	1.86 ±0.49	1.32 ±0.17	2.30 ±0.62	2.29 ±0.32	2.10 ±0.47	1.93 ±0.43	1.44 ±0.41	1.40 ±0.36	1.45 ±1.22	1.34 ±0.39
1[b]	2.70 ±0.20	1.41 ±0.14	2.18 ±0.19	2.02 ±0.08	1.16 ±0.13	2.49 ±0.83	2.41 ±0.39	2.69 ±0.23	2.43 ±0.18	1.83 ±0.18	2.62 ±0.80	4.34 ±1.43	2.02 ±0.10
3[c]	2.48 ±0.44	1.15 ±0.12	2.09 ±0.36	1.80 ±0.27	1.43 ±0.14	3.05 ±0.30	2.63 ±0.44	2.50 ±0.44	2.02 ±0.53	1.48 ±0.41	1.44 ±0.36	2.42 ±1.01	1.70 ±0.19
6[c]	2.24 ±0.28	1.50 ±0.33	2.34 ±0.24	1.92 ±0.25	1.12 ±0.12	2.31 ±0.46	2.35 ±0.21	2.27 ±0.24	2.06 ±0.05	1.62 ±0.24	2.30 ±0.21	2.72 ±0.29	1.72 ±0.12
Significance level	NS	NS	0.05	NS	NS	NS	NS	NS	NS	NS	0.05	0.05	0.05

[a] Eight (8) observations.

[b] Six (6) observations, except eight (8) for Menus 7, 8, 11 and 12.

[c] Six (6) observations.

[d] Standard deviation.

TABLE 10

Vitamin B_6 Content of Meal, Ready-to-Eat, Individual, During Cycling
mg/100 gms

Cycles	Menus												
	1	2	3	4	4a	5	6	7	8	9	10	11	12
0[a]	0.018 $\pm$0.01[d]	0.070 $\pm$0.01	0.045 $\pm$0.005	0.140 $\pm$0.01	0.060 $\pm$0.01	0.100 $\pm$0.01	0.047 $\pm$0.005	0.080 $\pm$0.03	0.089 $\pm$0.01	0.020 $\pm$0.00	0.073 $\pm$0.01	0.050 $\pm$0.01	0.068 $\pm$0.01
1[b]	0.068 $\pm$0.01	0.088 $\pm$0.01	0.052 $\pm$0.01	0.098 $\pm$0.01	0.070 $\pm$0.01	0.120 $\pm$0.02	0.050 $\pm$0.01	0.085 $\pm$0.01	0.075 $\pm$0.01	0.033 $\pm$0.005	0.053 $\pm$0.005	0.047 $\pm$0.005	0.070 $\pm$0.01
3[c]	0.075 $\pm$0.04	0.070 $\pm$0.01	0.043 $\pm$0.01	0.082 $\pm$0.02	0.057 $\pm$0.01	0.097 $\pm$0.02	0.037 $\pm$0.005	0.072 $\pm$0.02	0.057 $\pm$0.01	0.023 $\pm$0.005	0.037 $\pm$0.005	0.037 $\pm$0.005	0.057 $\pm$0.01
6[c]	0.057 $\pm$0.01	0.058 $\pm$0.01	0.043 $\pm$0.005	0.063 $\pm$0.01	0.050 $\pm$0.00	0.098 $\pm$0.02	0.040 $\pm$0.01	0.058 $\pm$0.01	0.060 $\pm$0.01	0.027 $\pm$0.005	0.047 $\pm$0.005	0.037 $\pm$0.005	0.048 $\pm$0.01
Significance level	NS	NS	NS	0.01	NS	NS	NS	NS	0.05	0.05	0.01	NS	NS

a Eight (8) observations.

b Six (6) observations, except eight (8) for Menus 7, 8, 11 and 12.

c Six (6) observations.

d Standard deviation.

TABLE 11

Effect of Cycling on the Vitamin Content of Meal, Ready-to-Eat, Individual
(Percent Retention)

Menu	Treatment	Vit. A	Carotene	Ascorbic Acid (R)[1]	Ascorbic Acid (T)[2]	Thiamine	Riboflavin	Niacin	Vit. B_6
1A	One Cycle	84	51	69	48	32	68	125	380
	Three Cycles	101	32	86	94	26	77	115	418
	Six Cycles	59	38	28	102	65	103	104	318
2	One Cycle	118	24	123	76	68	88	125	126
	Three Cycles	128	80	107	131	70	82	102	100
	Six Cycles	112	82	23	134	74	118	133	83
3	One Cycle	61	54	45	87	72	86	134	115
	Three Cycles	77	80	96	120	67	85	128	95
	Six Cycles	69	26	25	168	72	119	143	95
4	One Cycle	73	73	44	86	86	106	109	70
	Three Cycles	43	84	48	112	92	110	97	59
	Six Cycles	57	67	66	126	100	154	103	45
4A	One Cycle	45	80	64	82	74	85	88	117
	Three Cycles	35	76	78	103	90	95	108	95
	Six Cycles	27	73	26	120	93	160	85	83
5	One Cycle	55	106	49	66	89	103	108	120
	Three Cycles	47	79	28	115	103	127	133	97
	Six Cycles	47	87	59	140	116	197	100	98
6	One Cycle	72	52	89	70	95	156	105	107
	Three Cycles	65	38	119	88	92	160	115	79
	Six Cycles	54	9	60	105	154	207	103	86
7	One Cycle	58	88	70	96	117	184	128	106
	Three Cycles	57	109	63	133	126	177	119	90
	Six Cycles	37	106	54	177	117	244	108	72

1 Reduced

2 Total

TABLE 11 (Cont'd)

Effect of Cycling on the Vitamin Content of Meal, Ready-to-Eat, Individual
(Percent Retention)

Menu	Treatment	Vit. A	Carotene	Ascorbic Acid (R)[1]	Ascorbic Acid (T)[2]	Thiamine	Riboflavin	Niacin	Vit. B_6
8	One Cycle	73	54	112	100	88	163	126	94
	Three Cycles	79	102	156	123	72	145	105	71
	Six Cycles	48	105	68	183	100	170	107	75
9	One Cycle	31	84	178	91	77	126	127	166
	Three Cycles	48	27	93	133	75	124	103	126
	Six Cycles	36	32	86	102	73	168	112	135
10	One Cycle	50	32	108	75	72	144	187	73
	Three Cycles	51	24	121	94	68	140	103	51
	Six Cycles	38	21	47	180	75	171	164	65
11	One Cycle	40	76	75	39	73	392	300	94
	Three Cycles	41	17	113	58	71	374	167	74
	Six Cycles	22	23	58	72	116	453	188	74
12	One Cycle	35	53	79	95	67	187	151	103
	Three Cycles	37	18	63	121	90	190	127	84
	Six Cycles	23	26	43	137	82	239	128	71
Average of 13 menus									
	One Cycle	56	72	75	74	73	122	136	106
	Three Cycles	55	80	80	109	75	124	117	87
	Six Cycles	43	77	49	130	85	170	119	80

1 Reduced

2 Total

APPENDIX 1

Technical Characteristics for Meal, Ready-to-Eat, Individual (1961)

1. General

a. Scope: These characteristics pertain to the technical aspects of the development of the Ready-to-Eat Individual Meal to fulfill the military characteristics of operational rations.

b. Purpose: The Meal, Ready-to-Eat, Individual, will be issued to individuals for operational conditions which permit planned resupply, but preclude provision or utilization of either the Meal, Uncooked, 25-Man, or the Meal, Quick-Serve, 6 or 25 Man. For maximum flexibility of use as the tactical situation changes and the tactical commander requires, the Meal, Ready-to-Eat, Individual, will be capable of interchangeability and/or use in conjunction with the other operational rations described by the military characteristics.

c. Non-common characteristics: Technical characteristics provided herein pertain to the Meal, Ready-to-Eat, Individual, only and, in general, are not common to other operational rations.

d. Using elements: Theater of operations.

2. Design: The Meal, Ready-to-Eat, Individual, will meet the following design standards:

a. Nutritional adequacy: Meals will be designed so that any three provide the daily nutritional requirements set forth in AR 40-564 (including 3600 calories) for one man, and any one meal provides 1/3 the daily nutritional requirements (including 1200 calories) for one man.

b. Acceptability: At least 12 meals will be designed so that any one meal is suitable for breakfast, dinner or supper and any three are suitable as a ration. Food components will be developed in terms of maximum acceptability when eaten cold; variety will be sufficient to avoid rejection when the Meal, Ready-to-Eat, Individual, is consumed as the sole diet over a period of one week. Human engineering principles will be applied throughout development of food components.

c. Stability: All food components, in the packaging used for the Individual Ready-to-Eat Meal, will be capable of withstanding at least six months at 37.8°C without significant loss of nutritional adequacy, edibility, acceptability or utility, and will be capable of withstanding repeated freezing and thawing involving exposure, in the ration case, to temperatures as high as 51°C for as long as two hours per day, and as low as -54°C without significant loss of nutritional adequacy, acceptability and utility.

d. Utility: The meals will require no preparation other than opening of packages and no reconstitution except for beverage components.

APPENDIX 2

Conditions for Freeze-Thaw Cycling Test of Meal, Ready-to-Eat, Individual

Summary

Case lot samples of 13 different menus were subjected to 1, 2, 3, 4, 5, and 6 freeze-thaw cycles. Each lot consisted of a number of cases containing 12 different menus in separate cartons plus one case containing 12 cartons of menu 4A. All of the cases in each lot were exposed simultaneously to the test conditions. The temperature conditions and the time of exposure for a typical cycle were:

Temperature	Time of Exposure
-54°C	16 hrs.
22°C	24 hrs.
51°C	2 hrs.
22°C	4 hrs.

During the 16 hour soak at -54°C the temperature of certain food packets bottomed out at between -52° and -54°C.

Two lots of samples were handled concurrently -- one lot being exposed to the -54°C temperature while the other was thawing. The cycling tests were started on 16 Sept. and continued on a 5-day schedule until all 6 lots were completed by 17 Oct. As soon as the cycling of each lot was completed the cases were transferred to a 4.5°C room until needed for subsequent panel and nutrition studies.

Procedure

A number of preliminary observations were made prior to the actual temperature cycling tests. The objectives were to establish (1) the heat transfer rate between the contents of a case and its surroundings and (2) the magnitude of temperature variations within the case itself. The indicated observations were made by installing a cluster of strategically located thermocouples within the contents of a case and recording the temperature change when the case was buried in crushed dry ice; when the case was placed inside a -54°C cold box; and when the chilled case was exposed to room-temperature air. The temperatures for these preliminary observations were measured at 6 different locations inside the case by means of thermocouples. The locations are graphically shown in Figure 1. Thermocouples "A" and "B" were located in menu carton number 6. "A" was placed inside the date pudding packet and

"B" was placed near the center of the carton and adjacent to the accessory pack. Thermocouple "E" was located in menu carton number 8 inside the beef stew packet. "F" was placed in menu carton number 12 beside the potato patty pouch. "C" was located in the geometric center of the case at the corners of menu cartons 5, 6, 8 and 10 and "D" was located along the edges of menus 6 and 10 just inside the corrugated fiberboard.

The cooling rate curves for the dry ice samples are shown in Figure 2. It will be noted that the temperature variations were significant until the temperature started to bottom out at around -73°C. Because of this variation and because the temperature bottomed out at a lower level than desired it was decided to reject this method of chilling and utilize the controlled temperature of an environmental chamber. It was found in the latter instance that, after an exposure of 16 hours the temperature variations were negligible ranging between -52° and -54°C when the box was set to control at -54°C. The ambient temperature to which the samples were exposed during the freezing cycle whether it be that of dry ice (-78°C) or that of the environmental chamber (-54°C) had no appreciable effect on the relative configuration of the temperature profiles.

The temperature recovery or warming rate was determined by removing the case from a bedding of dry ice and recording the temperature as the case reposed on a shelf in naturally circulated room-temperature air. The temperatures were again measured by means of the thermocouples which were left undisturbed in their original positions. Figure 3 is a plot of the recovery or warming rate. This plot indicates that a period of about 25 hours is required for the internal temperature to level off with that of the surroundings when the initial temperature of the contents is -73°C and that of environment is 26°C. It was assumed from these results and then confirmed that a 24-hour warming period was sufficient when the initial temperature was -54°C.

The time table for the actual cycling tests was:

First day	- 4:00 p.m.	(A) Placed 1st lot of cases in cold cabinet.
Second day	- 8:00 a.m.	(A) Removed 1st lot from cold cabinet and exposed them to room temperature.
Second day	- 4:00 p.m.	(B) Placed 2nd lot of cases in cold cabinet.

Third day	- 8:00 a.m.	(A) Placed 1st lot of cases in 51°C room.
		(B) Removed 2nd lot of cases from cold cabinet and exposed them to room temperature.
	10:00 a.m.	(A) Removed 1st lot of cases from 51°C room and exposed them to room temperature.
	4:00 p.m.	(A) Replaced 1st lot of cases in cold cabinet to start next cycle.

This timetable was continued on a 5-day schedule until the required number of freeze-thaw cycles were completed. A deviation, however, was necessary during weekend periods. The lot which was placed in the cold cabinet on Friday at 4:00 p.m. was not removed until the following Monday at 8:00 a.m. and the lot beginning its thaw cycle at 8:00 a.m. on Friday was not placed in the 51°C room until the following Monday at 8:00 a.m. The weekend exposure for each batch of cases is shown below:

Lot & Cycle Number	Weekend Exposures -54°C	Weekend Exposures 24°C
6	2	1
5	1	1
4	1	0
3	0	1
2	1	0
1	0	1

Each lot was assembled and numbered for ease in handling. Those subjected to one freeze-thaw cycle were numbered 1; those subjected to two freeze-thaw cycles were numbered 2, etc. Lots 1, 3 and 6 each consisted of 8 cases containing menus 1-12 and one case of menu 4A. Lots 2, 4 and 5 each consisted of 5 cases of menus 1-12 and one case of menu 4A.

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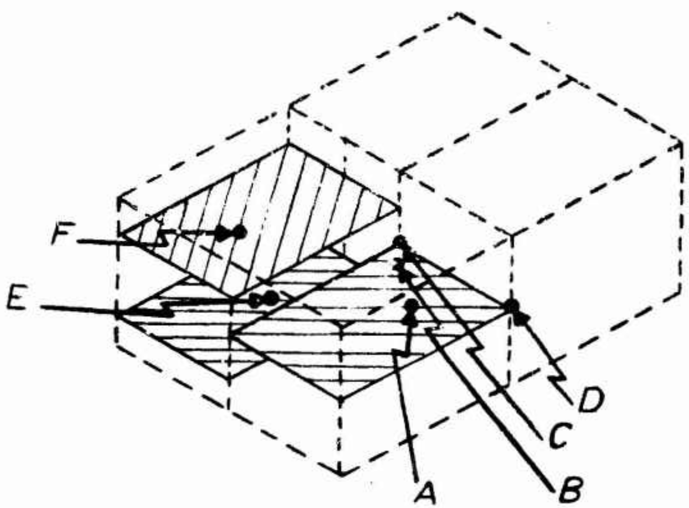
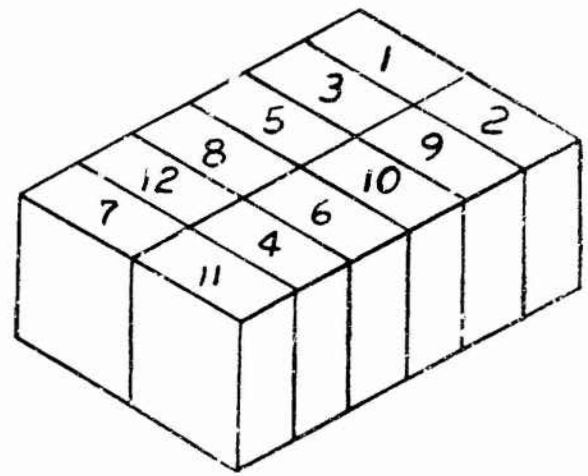
THERMOCOUPLE LOCATIONS



THERMOCOUPLE
POSITIONS

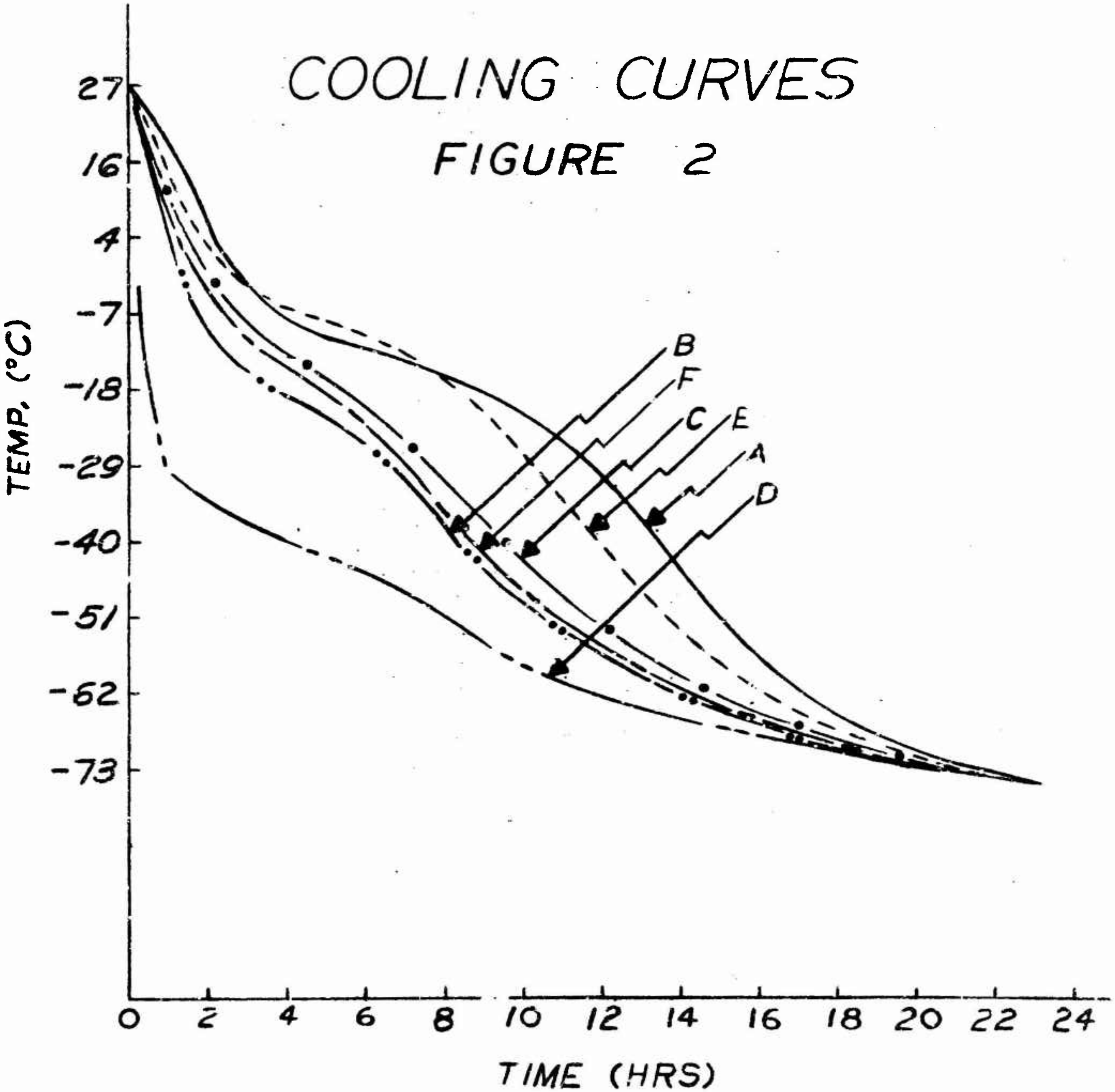


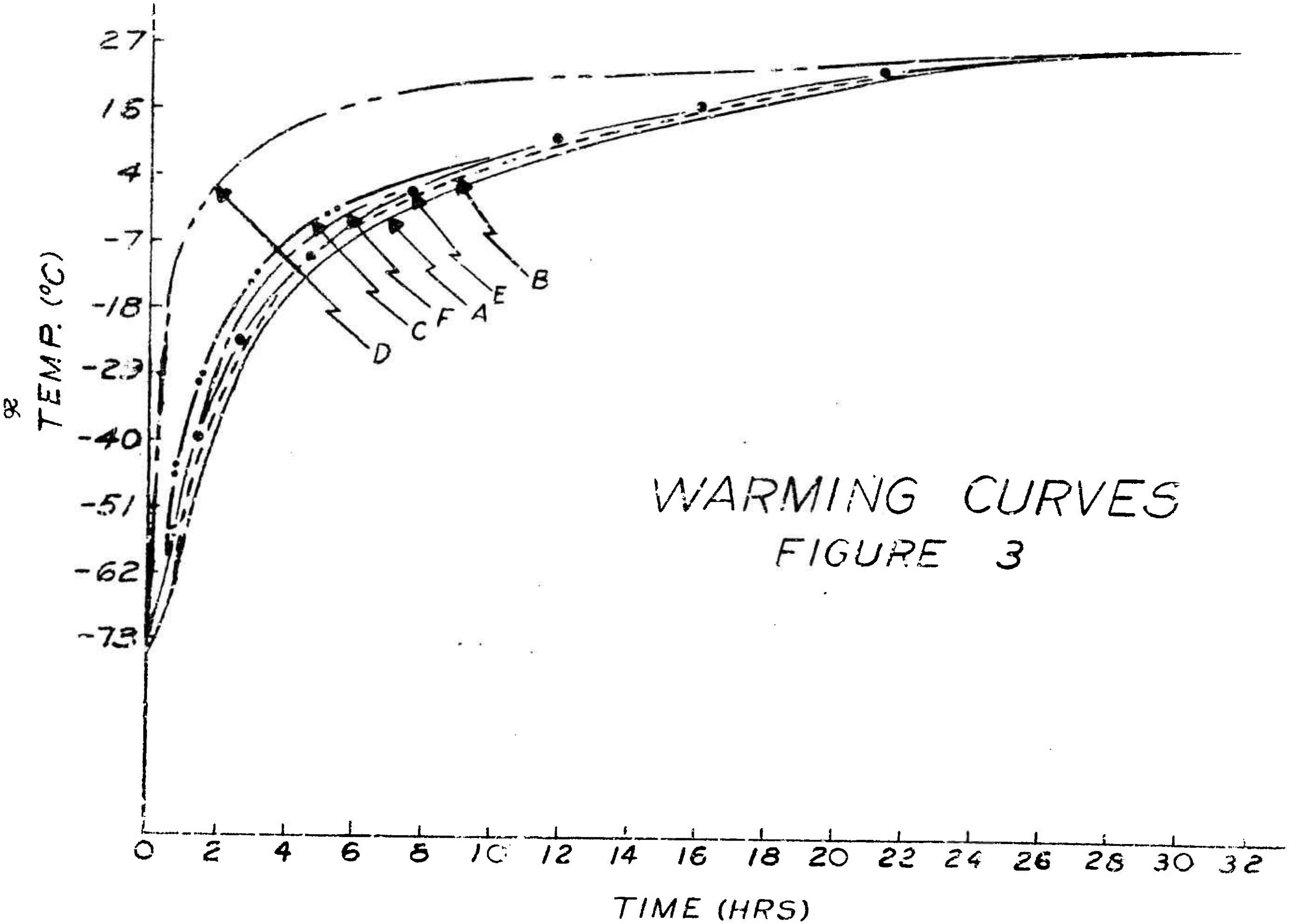
MENU CARTON
POSITIONS

FIGURE 1

COOLING CURVES

FIGURE 2





WARMING CURVES
FIGURE 3

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13. ABSTRACT

A study was conducted to determine the vitamin stability of the Meal, Ready-to-Eat, Individual, after exposure to 1, 3, and 6 freeze-thaw cycles under controlled conditions. Prior to and after cycling, replicate analyses of thirteen menu composites were made for vitamin A, carotene, ascorbic acid, thiamine, riboflavin, niacin, and vitamin B_6 contents. Of these vitamins, losses occurred in all except riboflavin and niacin.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Stability	8		7			
Vitamin content	8,9		7			
Meal, ready-to-eat, individual	9		7			
Military rations	9		7			
Freezing			6			
Thawing			6			
Ascorbic acid	9		7			
Carotenes	9		7			
Nicotinic acid	9		7			
Riboflavin	9		7			
Thiamine	9		7			
Vitamin A group	9		7			
Vitamin B complex	9		7			

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